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THE TWO-CIRCLE GONIOMETER

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INTRODUCTION

Crystallographic measurements were first made by simple contact instruments, which gave the angle between a pair of crystal faces. This method was soon improved by employing the crystal faces as reflecting surfaces, and measuring the angle thru which it was necessary to turn the crystal in order to bring successive faces of a zone to the same position of reflection. Measurement thus by zones, with a new adjustment of the crystal for each zone measured, was adopted by crystallographers as a general procedure, and used for many decades; and a variety of instruments was devised for this purpose, some of great accuracy. The use of such one-circle reflecting goniometers is fully described in numerous accessible works in English.

The next improvement in crystal measurement had for its object the determination of complete angular relationships between all the faces of the crystal, expressed in terms comparable to those employed in locating positions on the earth's surface,—latitude and longitude. This plan was first used by the English crystallographer W. H. Miller in 1874; and three instruments based upon it were independently described, almost simultaneously.¹ These were soon followed by others of still greater complexity² upon which both polar coördinate angles and complete zonal measurements could be made at a single setting of the crystal.

Goldschmidt's two-circle goniometer, one of the first to be described, has since been constantly improved, and is an essential part of a complete system of descriptive crystallography which

¹ V. Goldschmidt, *Z. Kryst. Min.*, **21**, 210, 1892; E. Fedorov, *Verh. Min. Ges. Russia* **26**, 458, 1889; *Z. Kryst. Min.*, **21**, 574, 1893; S. Czapski, *Z. Instrumentenkunde*, **13**, 1893; *Z. Kryst. Min.*, **25**, 620, 1896.

² G. F. H. Smith, *Mineral. Mag.*, **12**, 175, 1899.

is coming into general use, especially in America. Most of the papers describing the use of this instrument and the methods of discussing the resulting measurements are, however, widely scattered in German publications. No complete instructions, in English, for the use of Goldschmidt's two-circle methods have ever appeared in print; such incomplete papers as exist³ are relatively inaccessible.

The advantages of these methods are, however, so great, and the number of workers using the instruments so considerable, that it seems desirable to publish a rather full account of the principles and methods of two-circle goniometry and of its graphic expression, the gnomonic projection. It is planned, accordingly, to have an article on some phase of this method appear in successive numbers of this journal for at least the next six months, and ultimately to reprint these in a single pamphlet for the use of teachers and students of crystallography.

THE INSTRUMENT

In the familiar spherical projection the crystal faces are represented by the points of intersection of the face-normals with the surface of a sphere described about the crystal center. The relations of these points upon the sphere are known, if we determine the angular distances between them (measurement of interfacial angles) or if we determine the position of each one with reference to a set of coördinates (measurement by angular coördinates). These operations are strictly analogous to well known geographical operations; the first is comparable to triangulation, or the measurement of angular distances between points on the earth's surface; the second is like the determination of localities by latitude and longitude—that is, by reference to an equator and a meridian as fixed coördinates. The latter operations are so nearly alike that it is found convenient to retain the geographical terms for the crystallographic coördinates, and we accordingly speak of the equator and meridian of the crystal.

Any great circle of the sphere of projection may be taken as equator and the pole will lie at a distance of 90° therefrom. Any great circle at right angles to the equator may be taken

³ C. Palache, *Am. J. Sci.*, 2, 279, 1896; A. J. Moses & A. F. Rogers, *Sch. Mines Quart.*, 24, 1, 1902; see also the brief account in: A. E. H. Tutton, *CRYSTALLOGRAPHY*, 462–481, 1911; and the textbook based on the method: T. L. Walker, *CRYSTALLOGRAPHY*, 1914.

as first meridian. In practice the choice of coördinates is limited to a few cases.

The means of applying this principle to crystal measurement is found in the *two-circle goniometer* of which fig. 1 is an illustration. Its construction is best explained by reference to the outline diagrams, figs. 2 and 3. *H* is the horizontal circle revolving about the axis *h*, graduated and provided with fine adjustment and vernier. Rigidly attached to *H* by an arm and at right angles to it is the vertical circle *V* revolving about the axis *v* and also graduated and provided with fine adjustment.

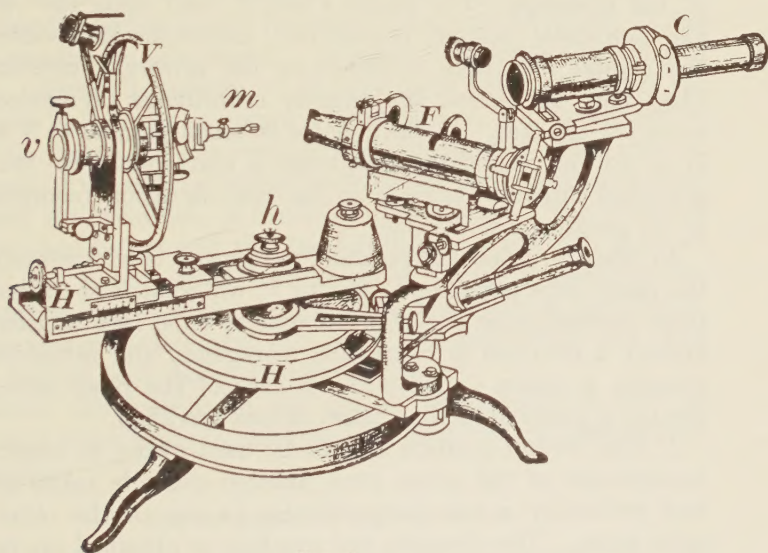


FIG. 1.

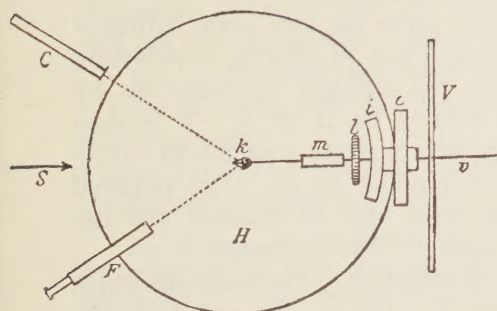


FIG. 2.

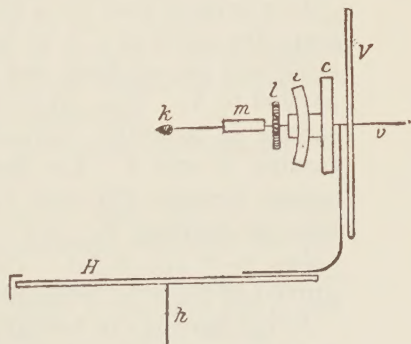


FIG. 3.

The axis v supports an adjusting device such as is found on the ordinary goniometer and upon it the crystal is mounted by means of a carrier m capable of independent adjustment.

The collimator C and telescope F are horizontal; they may be moved relative to each other and the angle between them measured.

By revolution of V (from an arbitrary zero thru an angle φ) each face of the crystal may be brought perpendicular to H. By revolution of H (thru angle ρ from an arbitrary zero) the face may be brought perpendicular to S, the bisectrix of the angle CkF, also, and will then reflect the signal upon the crosshairs of the telescope. The angles v and h , read upon the vertical and horizontal verniers respectively, determine the position of the crystal face with reference to the arbitrary coördinates. They may be termed the angular coördinates (Winkelcoördinaten) of the face. If the equator is taken parallel to V and if H is the first meridian, then angle φ corresponds to the geographical longitude, angle ρ to the pole elevation (complement of the geographical latitude).

In practice, whenever possible, the crystal is so mounted that the prism zone is perpendicular to V; or, what is the same, the plane perpendicular to the prism zone, a cube face in isometric system, a pinacoid in hexagonal, tetragonal, and orthorhombic systems, is taken as the *pole*. A face of the prism zone, preferably a pinacoid, is then taken as first meridian.

If this normal position cannot be used owing to absence or imperfection of the prism zone, another plane is taken as *pole* and preferably a face perpendicular to one of the other two axial zones. The elements and symbols so obtained are readily transformed to the normal form by interchange of axes.

It is evident that for a given position of collimator and telescope the value of $\rho = h_0$ for the polar position of the vertical circle will be constant and will serve for any plane adjusted parallel to V. This value, h_0 , is found as follows: A reflecting surface is mounted, centered, and brought to reflection by turning H and V. Let the reading on H be h_1 . V is then turned through 180° and the surface again brought to reflection by turning H. Let this reading be h_2 . The required value, $h_0 = \frac{1}{2}(h_1 + h_2)$. This value may be checked and improved by repeated measurements on other surfaces.

Every face may be brought to reflection in two positions which yield, however, the same values of φ and ρ . If v and h are the

angles read for a face when v stands in that quadrant of H near the observer and the telescope (h less than h_0) and v' and h' the angles when V stands in an opposite quadrant of H then:

$$v = 180^\circ - v',$$

$$h - h_0 = h_0 - h' = \rho.$$

Averaging these two readings increases the accuracy of measurement but all ordinary requirements of accuracy are fully met if a single reading is taken for each face, preferably in the first position.

The angle between collimator and telescope, once fixed at a convenient position (about 70 degrees), must not be altered during the measurement of a crystal. In practice it need not be changed often. Since all readings on H have to be subtracted from the constant h_0 in order to obtain ρ for each face, it is convenient to have the value of h_0 an even number of degrees. This may be attained by the method of trial, shifting the angle and determining h_0 until the condition is fulfilled. The clamp of the telescope should then be set and the fine adjustment screw also clamped tight, lest it be moved inadvertently during a measurement. This proceeding is laborious, but saves much time in calculation; on the writer's instrument this angle, and accordingly the value of h_0 , has not been changed for twenty years.

Should the instrument get out of adjustment, it may be placed in order again in accordance with directions furnished by the maker.

ADJUSTMENT OF THE CRYSTAL

The value of the constant h_0 having been determined,¹ the next step in the measurement of a crystal is its correct adjustment on the goniometer. The method to be used depends upon the symmetry of the crystal and the faces present. Most crystals will fall into one of four cases, which may be defined as follows:

Case I. The pole face present and reflecting.

Case II. The pole face defined by a zone perpendicular to it, (prism zone).

Case III. The pole face defined by a "ring" (group of faces making equal angles to the base, as a pyramid or rhombohedron).

¹ According to the graduation of H , the value of the reading h_0 may be 90° greater or less than the h for a prism face. In the latter case in what follows, for $(h_0 - 90^\circ)$ read $(h_0 + 90^\circ)$ and for $(h_0 - \alpha)$ read $(h_0 + \alpha)$.

Case IV. The pole face defined by a zone and a face in the zone making a known angle to the pole face.

Case I. The pole face (f) present and giving a good reflection.

The crystal is fixed upon the adjustment table with hard cement as near the desired position as may be and a corner of the face is centered. H is now brought to the reading h_0 and the reflection from f centered on the crosshairs by use of the adjusting tables. When properly adjusted, that is when parallel to V , the reflected signal should remain stationary on the crosshairs during a revolution of V .

Case II. The pole face (f) defined by a zone perpendicular to it (prism zone in any system).

An edge of the prism zone is centered and adjusted to the horizontal crosshair. H is clamped at $h_0 + 90^\circ$ and the reflections from two adjacent faces of the zone are brought to the center of the crosshairs by means of adjusting tables. H is then loosened, the edge again centered and the whole repeated as often as necessary. Other faces of the zone are then examined and if necessary the adjustment bettered. When the prism zone is thus adjusted at $(h_0 + 90^\circ)$, f , the pole face, is at h_0 and if present its reflection should be on the crosshairs when H is brought to h_0 . This case is important since the plane at right angles to the prism zone is the normal plane of projection in all systems and this position gives simple and direct results in the calculation. The prism zone is rarely lacking entirely and even when its faces are poor or striated its correct adjustment is possible.

Adjustment by the prism zone is more accurate than that by the pole face and should be used in preference to the latter where both are possible on a crystal.

Case III. The pole face (f) defined by a "ring."

(a) The angle (α) made by the faces of the "ring" to (f) is known.

The crystal is placed on the goniometer with one face of the ring (F) opposite a tilting screw (T_1 , see below, p. 31) and H is clamped at $(h_0 + \alpha)$. The image of F is brought upon the cross hairs of the telescope by movement of V and T_1 . Another face of the ring is then brought to reflection, H again clamped at $(h_0 + \alpha)$, and the image brought upon the crosshairs by movement of V and T_2 . By one or two repetitions the two faces

will be adjusted, when images from the remaining faces of the ring should fall on the vertical crosshair at the same position of H.

(b) The angle (α) made by the faces of the "ring" to the pole face (f) is unknown.

The crystal is set on the adjusting table with its vertical axis as nearly upright as possible, and three or more faces of the ring are successively brought to reflection by motion of V and H. The angle of each on the vernier of H is recorded, and h_0 subtracted from each. The average of these values is an approximate value of (α) and may be used for an approximate adjustment as in (a) above. Repetition of this procedure once or twice will give an accurate value for (α) and a final adjustment.

This case is important, and is commonly met with in rhombohedral crystals and in pyramidal crystals of the three rectangular systems in which the prism zone is lacking or poorly developed.

Case IV. The pole face (f) defined by a zone and a face (F) in the zone making a known angle (α) to the pole face.

The crystal is set on the adjusting table with the given zone opposite to one of the tilting screws (T_1 , see below, p. 31), H is clamped at ($h_0 + \alpha$) and F is brought to reflection by movement of V and T_1 . H is now unclamped and successive faces of the zone are brought to reflection by movement of H and V. In general the images will lie above or below the horizontal cross hair. Movement of V and of T_2 will correct their position until by movement of H all faces of the zone come to reflection on the horizontal hair without movement of V. H is again clamped at ($h_0 + \alpha$), and the process repeated until F is at the angle ($h_0 + \alpha$) and the zone is vertical, when the crystal is adjusted.

This case is most frequently met with in monoclinic crystals in which the prism zone is absent or poorly developed.

Abnormal positions.—

It is always desirable that the crystal should be measured in its normal position, that is, with vertical axis normal to V. If the habit of the crystal prevents this choice or makes such adjustment difficult, the next simplest proceeding is to choose one of the other axial zones as the equatorial (prism) zone. This case arises not infrequently in the monoclinic system with crystals of the epidote habit in which the zone of orthodomies is the major zone. If this zone be taken as prism zone, the clinopinacoid becomes pole face. Adjustment and measurement

proceed as in normal position; discussion of the results will be described on a later page.

Abnormal orientation for measurement is often useful in cases of symmetrical distortion in isometric crystals where an octahedron or dodecahedron face may be taken as pole face instead of the normal cube. In the case of twin crystals, unless the twin plane is a face of the prism zone, two measurements are sometimes desirable, one with one unit of the group in normal position for determination of the forms present, a second with the twin plane vertical and some zone containing it and common to both crystals in equatorial position to enable a simpler discussion of the twin relation in projection.

It sometimes happens with crystals of lower symmetry, or where there is extreme distortion, or but a fragment of the crystal at hand, that it is impossible to orient the crystal without a preliminary measurement. Generally it suffices to measure a few interfacial angles, which may be done rapidly as follows: Any good face is adjusted as pole face (Case I), that is, its reading on H is h_0 . As many other faces as may be necessary are then successively brought to reflection and readings on H taken for each. Subtracting h_0 from each reading, the interfacial angle between each face and the pole face is obtained. It is also evident that the readings on V for a zone adjusted as prism zone, and those on H for vertical zones, furnish interfacial angles which may likewise be used for orientation of the crystal.

PRACTICAL DETAILS OF CRYSTAL MEASUREMENT

The crystal to be measured should be studied under the hand lens, loupe or binocular, and its symmetry determined, if possible. One or more sketches should then be made on such a scale and with such accuracy that each face may be surely recognized when seen thru the telescope of the goniometer, even when inverted, as it is with most of the lens systems. The sketch should be made on the top of the sheet of quadrated paper which is to be employed to record the measurements, and each face in the sketch should receive a serial number, the order of numbering being quite arbitrary. In the case of very small crystals the sketch can sometimes be made more easily on the goniometer itself, but it should never be omitted.

The crystal having been studied, and the zone, face or "ring" selected which is to be used for its adjustment on the instrument,

it is mounted with hard wax on a brass pin fitting the adjustment table, with its long axis as nearly parallel to the length of the pin as possible. The pin is then placed in the socket, but before clamping it there some face of the prism zone or the "ring" should be brought as nearly as possible opposite to one of the tilting screws of the adjusting table, by rotating the pin in its socket. Let this screw be indicated in what follows as T_1 , the other one as T_2 . The more exactly this position is attained, the more rapidly will the whole adjustment proceed; and in case of zones or "rings" with but few faces, close approximation as described below is indispensable.

The pin is clamped and the crystal centered. The chosen face is then brought to the required position (according as it falls in Case I, II, III, or IV above) by movement of V and T_1 . If when this is accomplished it is found that T_1 is not horizontal it is well to slightly loosen the pin in its socket and, holding the pin with one hand so that the image from the face remains near the crosshair, to turn the vertical circle with the other hand until T_1 comes into the horizontal position. The pin is then clamped and the adjustment of the first face repeated. The reason at the base of this operation is that if the face is opposite to one tilting screw, T_1 , it is parallel to the other, T_2 , and will be rotated by any movement of T_2 required to adjust a second face only in its own plane, and thereby but slightly disturbed in its position relative to T_1 .

A second face, chosen as nearly as may be at right angles to the first, is now adjusted, T_2 alone now being used, together with V . Returning to the first face, its position is verified and readjusted with T_1 , and in turn the second face is reexamined and adjusted with T_2 ; and this is continued until both faces are correct. The zone or "ring" is then tested in its entirety and any slight alterations made that may be needed, care being taken to use at any time only that tilting screw which is most nearly horizontal.

The adjustment should now be tested by examination of other "rings" or vertical zones that may be present, or in any other way possible, and if it prove satisfactory, the crystal is ready for measurement.

Measurement is effected by bringing each face in succession to reflection, identifying it upon the sketch, clamping both circles, setting the image with the tangent screws exactly upon

the crosshairs of the telescope, and reading both verniers. The order in which the faces are measured is a matter of indifference. It is common practice to measure first the prism zone in its entirety, especially if it be rich in faces. Rings may then well be measured, or each series of vertical zones between prismatic faces and the base. Much depends upon the crystal, its size and complexity, and upon how much is known of its symmetry before measurement. If it be so large that only a part of it is visible in the telescope at one time, it is generally best to measure all visible faces without regard to zones and then, shifting by means of the sliding screws to another area, to repeat until the circuit is complete.

The lens systems employed in Goldschmidt goniometers of different models are so different that it is impossible to give exact instructions for their varying use. In general, measurements should be made with the system of lowest magnification practicable. If a crystal have both large smooth faces and minute ones it is well to measure all the larger faces with a low power and large image and then, shifting to a higher power, to go over it again for the smaller faces, with less reflecting surfaces. In the case of very small crystals it is necessary to use the higher magnifying systems thruout, altho the measurements so obtained are of inferior accuracy.

The measurement of each face is entered on a single line of the paper. Leaving a blank of several squares on the left hand margin, for the entry of the symbol when determined, there should be entered first a quality index indicating the perfection of the signal. The writer employs for this purpose five greek letters, α denoting a perfect signal; ϵ an image so faint or blurred that little dependence can be placed upon the reading; with three intermediate grades. The number of the face occupies the next column. Next comes the angle (v) read on the vertical circle and after it the angle (h) read on the horizontal circle. For each of these a space of three squares is needed. If it is desired to make any further notes on the reading they should be confined to a small space at the extreme right-hand side of the line, leaving the intermediate space for calculations connected with the projection and discussion of the measurements. The notes of successive measurements may occupy successive lines if figures are made small and distinct. Quadrated paper with 5 mm.

spaces is convenient, and two figures may be easily written in each square.

It is of great importance that the measured face be absolutely identified in the sketch, so that it may receive its proper number; otherwise much confusion ensues in projection and the discussion of results. The crystal should always be left on the instrument without disturbing its adjustment, at least until a projection has been made; then if any discordance appears between sketch and measured (plotted) position, or any doubt arises as to the correctness of entered angles, the face in question may be at once reexamined and verified. On setting off, on the two verniers, the two angles entered in the notes, the face corresponding to them should come again to reflection on the crosshairs.

The instrument permits all the faces of one end of the crystal, including prism faces, to be measured at one setting. Should the other end also be developed, it is necessary to invert the crystal, adjusting it with the same zone as prism zone and the same face as first meridian, thus establishing the relation between the faces of the two ends.

The measurement of faces which are smooth but too dull to reflect the signal is a special difficulty, to meet which several methods have been devised. One simple one is sometimes effective for crystals which have enough reflecting faces to permit adjustment. The dull face is brought as nearly to reflecting position as may be done by observing maximum illumination. It is then touched with a drop of alcohol, or even water, from the tip of a small soft paint brush. The liquid at first forms a curved surface, but as it evaporates there is an instant when the film is practically a plane, adhering to the surface of the face; this film may reflect an image of the signal long enough to permit of the accurate setting of the signal on the crosshairs. Large dull faces may sometimes be measured by causing slips of thin cover glass to adhere to them by a drop of oil.

The measurement of faces giving multiple reflections involves another set of problems. All images should be measured and if possible, by means of the eyepiece provided with a blende (shutter), the portion of the face yielding each should be identified, and the facts entered in a special sketch of the face. The position of the typical or normal facet will probably be best recognized when the measurements are plotted in the projection and the zone lines drawn.

THE TRAP QUARRY AT MERIDEN, CONNECTICUT

EARL V. SHANNON

U. S. National Museum

While not a famous locality in the sense that it has furnished minerals for a long period of time or become widely mentioned in the literature, the trap quarry at Meriden is a mineral locality easily reached by collectors, and it affords a plentiful supply of several minerals. It is located about $2\frac{1}{2}$ kilometers ($1\frac{1}{2}$ miles) northwest of Meriden station in the eastern edge of the Hanging Hills, and only a short walk from the end of the North Colony Street car line. Like most trap quarries in Connecticut, this quarry is opened in the middle diabase sheet, an extrusive lava flow which lies between beds of massive shale and sandstone. Here the trap is a vesicular lava, and is in two distinct flows. The rock which is quarried and crushed is mostly an amygdaloidal basalt, which is considerably altered. Near the top of the lower flow there is much rock which has a deep maroon color and contains small cavities filled with calcite and deep-green diabantite.

The secondary minerals of the trap are deposited in amygdaloidal cavities which may reach 20 centimeters in diameter and in veins up to 10 cm. wide which may persist for 20 meters. The most abundant mineral is colorless to pale yellow calcite, which forms groups showing varied crystal habit. The crystals reach 2-3 cm. in diameter; many of them are scalenohedral and display a number of forms. Quartz is common in druses of brilliant crystals lining cavities and coating other minerals, much of it being of a pale amethystine hue. Chalcedony and other forms of amorphous or crypto-crystalline silica occur lining geodes or filling veins solidly. Anhydrite occurs in large pearly masses showing cleavage surfaces often 10 cm. or more broad. There is abundant evidence that anhydrite has been present in almost universal distribution, but it now remains undissolved only in the centers of the less pervious blocks of rock. Molds of anhydrite crystals varying from stout prisms to exceedingly thin sheets are abundant everywhere. Anyone who entertains a doubt as to the origin of the rectangular molds in the New Jersey zeolite specimens would surely have that doubt dispelled by visiting Meriden. Some of the veins and large amygdaloidal cavities are lined with fine little datolite crystals; these are to be described in the *Proc. U. S. Nat. Museum*.

GOLD IN BOLIVIAN WOLFRAMITE CONCENTRATES

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Most of the year of 1917 was spent by the writer in Bolivia, investigating the primary markets of tungsten-bearing ores and concentrates. At this time Bolivia was one of the largest producers of these products, exceeded in this respect only by Burma and the Shan States, and by the United States. Bolivian tungsten ores find their way into two market centers, the cities of Oruro and La Paz respectively, the former being by far the more important. Generally speaking, the ores coming into the market thru Oruro are the more desirable, particularly for direct smelting, because of their relative freedom from objectionable impurities, and their low manganese content, in this latter respect excelling, in many instances, the ferberites of Colorado.

Ores coming into the La Paz market are diversified in character, varying from almost pure huebnerites from the country about Saya, to copper-bearing wolframite-scheelite mixtures from the mines above the perpetual snow-line on the way over to the Yungas. Many lots of ore changing hands in La Paz are high in arsenic, present usually as arsenopyrite. The arsenopyrite does not appear to occur in actual admixture with the tungsten-bearing minerals, but in quartz stringers that seem to interlayer with them. It is not unusual to find free gold occurring with the arsenopyrite in these quartz layers.

One afternoon I was asked, by a prominent Bolivian tungsten miner, if gold could be readily and cheaply recovered from tungsten concentrates without detracting from the market value of the latter. It developed that he had been given a sample of concentrates that was claimed to assay 125 grams (4 ounces) in gold. This sample was given me and examination proved it to contain some 1400 grams (45 ounces) of gold (something over \$900.00 U. S.) per ton, all free milling and consequently readily recoverable by pan-amalgamation or some similar process.

A few days later the property from which these concentrates had come was visited. In reaching the mines from La Paz we took advantage of almost every means of travel, ancient and modern, excepting aërial. The mines were stated to be near a small native village called La Joya (the jewel). It was, to my knowledge, the only tungsten producing property west of the

railroad extending between La Paz and Oruro. We left La Paz by train about 2 P.M., and arrived at Oruro something after 9 the same evening. Oruro sprawls out on the pampa at an altitude of about 4000 meters and is defenseless against the dust-laden winds that move at will (or without will) over these high, perfectly flat, treeless and almost vegetationless expanses.

The following morning, bright and early, we traveled back over the same railroad as far as a little station named Eucalyptus (just why no one knew). Here we found awaiting us a non-descript vehicle drawn by two flighty straw-burners (mules), which took us to the eastern bank of the river Desaguadero. We were ferried across this stream on a flat, home-made ferryboat guided by a wire and propelled by poles. A "camion" took us the rest of the way to the village of La Joya. This portion of the trip was made peculiarly interesting by a most pronounced and deceptive series of ever-changing mirages; houses and trees were distinctly seen where no houses nor trees existed, everything appearing to arise from a sheet of water. Reaching La Joya saddle-mules were provided for a portion of the remaining distance up-grade to the mines; and the last few hundred meters were covered on foot.

The property was a small producer, shipping an average of 30 quintales (about $1\frac{1}{2}$ tons) monthly of a good grade of wolframite concentrates, made by the most primitive methods imaginable. Any of these concentrates could be "panned," using an ordinary shovel, and strong gold color would develop. While these concentrates, on an average, may not have assayed as high in gold as the sample originally examined, there is no question that they did contain uniformly appreciable quantities of gold, which had gone to the market without separation or recovery and had probably found its way into ferrotungsten and, further along, into the high speed steel made therefrom.

One could not help wondering how much gold has been thus lost,—not thru failure to recover it from the output of this relatively insignificant producer of tungsten concentrates—but thru failure to examine Bolivian tungsten ores and concentrates in general, and, indeed, similar materials from other localities.

Is it not permissible, too, to indulge in a little speculative dreaming, and to wonder if such gold may not bear a similar relation to tungsten as the radio-active lead bears to the uranium with which it is found associated?

NOTES AND NEWS

On December 7, a party consisting of the following members of the Philadelphia Mineralogical Society: Messrs. Biernbaum, Boyle, Flack, Ford, Frankenfield, Gordon, Hagey, Jones, Knabe, Oldach, Trudell and Van Artsdalen, spent a most interesting and delightful day at the beautiful home of Colonel Washington A. Roebling, at Trenton, N. J., viewing portions of his immense mineral collection.

The party was greatly impressed by the many rare, beautiful and unique specimens seen and handled. The comfort of the visitors was most carefully looked after by the Colonel and his household and when the party departed, about four o'clock, it was with a deep feeling of appreciation and gratitude to Colonel Roebling for his kindly courtesy in extending the privilege of viewing such a magnificent collection of wonders.

H. W. T.

AMETHYST QUARTZ IN SERPENTINE. H. E. MCKINSTRY. *West Chester, Pa.*—In an account of the minerals of Brinton's Quarry, Chester County, Pa., published in this journal,¹ I stated that the reported occurrence of amethyst at this locality was probably in the adjacent gneisses and not in the serpentine. Recently, however, I have seen in the collection of Mr. Willard Brinton of West Chester, Pa., a specimen of the amethyst from Brinton's Quarry collected by Mr. Joseph H. Brinton. It is an aggregate of closely-crowded small crystals, resembling in form the drusy quartz so common in the serpentine, but showing an amethystine tint. Amethyst should therefore be placed among the weathering products in the paragenetic list of the minerals from this locality. Its occurrence in the serpentine of this neighborhood is so unusual that it is certainly worthy of note.

THE SPECIES RANK OF GUADALCAZARITE. EDGAR T. WEERRY. *Washington, D. C.*—While engaged in the study of the nomenclature and classification of the sulfide minerals, in connection with work at the U. S. National Museum, the writer was impressed by the weight of the evidence that mercuric sulfide, HgS , is trimorphous. As this view has been discounted in most recent mineralogy books, a brief reference to the situation seems worth while. The two best known forms of this compound are: cinnabarite, which crystallizes trigonal-trapezohedral, is red in color, and has the specific gravity 8.1; and metacinnabarite, which is cubic-tetrahedral, black, and 7.8 in sp. gr. The name guadalcazarite was given by Petersen in 1872 to a mercuric sulfide containing small (and negligible) amounts of zinc and selenium, of rhombohedral form, black color, and the still lower specific gravity 7.15. In 1890 Melville described rhombohedral-hemimorphic crystals from New Almaden, California, with black color and the specific gravity 7.12. He called it metacinnabarite, and the occurrence is so referred in the mineralogy books but the properties are those of guadalcazarite as above listed. As a complete difference in crystal form is ordinarily regarded as sufficient evidence of individuality of species, and as in this case so diagnostic a property as specific gravity points in the same direction, it is concluded that *guadalcazarite* deserves the rank of a definite mineral species.

¹ McKinstry, H. E. The Minerals of Brinton's Quarry, Chester Co., Pa. *Am. Min.* 1, 61, 1916.

PROCEEDINGS OF SOCIETIES
NEW YORK MINERALOGICAL CLUB*Regular Monthly Meeting, Wednesday, December 10, 1919*

The regular monthly meeting of the New York Mineralogical Club was held in the American Museum of Natural History on the evening of December 10th, at 8.15 P.M. The President Dr. George F. Kunz presided, and there was an attendance of 25 members. Mr. J. B. Erickson and Dr. John B. Ferguson were duly elected, and Mr. William Maurer was proposed for membership.

The president then introduced the speaker of the evening, Dr. John M. Clarke, state geologist of New York, who made an address on "High Lights and Shadows in New York Geology and Mineralogy." After giving some highly interesting reminiscences connected with the early days of the New York Geological Survey, Dr. Clarke spoke of the present work of the Survey, referring to the hypothetical average seeker after geological information, whom he quaintly characterized as "the man from Steventown." He made an appeal for coöperation among geological workers thruout the state, and stated that the means of handling every scientific problem should now be possible thru such a coöperation among state officials in the various departments as had resulted from the handling of war problems. He spoke of the necessity of coöperation between similar departments and Surveys in other States.

Turning to the darker side of the administration of the New York State Survey, he deplored the present difficulties encountered in printing scientific papers and reports, and stated that there were at present two memoirs and 15 bulletins ready for publication which must wait for the action of the Legislature to appropriate funds for their printing. In this connection the speaker appealed to the New York Academy of Sciences for a memorial to the State Legislature, asking that this highly important material be printed. Dr. Clarke dwelt on the mineral wealth of New York, which was represented not by precious metals, but largely by such useful non-metallic products as salt, gypsum and limestone.

In speaking of mineralogical and geological "fakes" he called attention to the fact that this was the fiftieth anniversary of the birth of the "Cardiff Giant." He outlined the history of this historic fake and spoke of James Hall and his connection with the Cardiff Giant, reading several pages from his manuscript of the Life of James Hall, which related to this phase of New York Geological History. Passing to other deceptions which have been imposed upon the New York public, he enlarged upon spurious mining claims, stating that some millions of dollars have been taken from the people of the State in the last few years through the medium of bogus mining propositions. He gave a very interesting history of the alleged gold-bearing sands of the Adirondacks including the Glens Falls scheme, the Suttven Process, and the Lowville gold boom. In this category he included the platinum excitements which have from time to time been agitated by unscrupulous promoters, and which were all based on the alleged finding, about 30 years ago, of a platinum nugget at Plattsburg. He also touched upon fraudulent oil and gas companies. At

the close of Dr. Clarke's address it was moved that a resolution be prepared asking the New York Legislature to expedite the printing of the scientific papers now awaiting publication, as Reports of the New York State Museum. On a motion by Mr. R. M. Allen, a vote of thanks was extended to Dr. Clarke for his most interesting address.

Mr. Ashby showed and distributed to the members some small crystal mounts, appropriate to the display of loose crystals. The meeting was adjourned at 10 P.M.

HERBERT P. WHITLOCK, *Recording Secretary.*

PHILADELPHIA MINERALOGICAL CLUB

Wagner Free Institute of Science, December 11, 1919

A stated meeting of The Philadelphia Mineralogical Society was held on the above date, with the president, Dr. Burgin, in the chair. Twenty members and 28 visitors were present. Dr. Alfred C. Hawkins, Wilmington, Del., was nominated for active membership.

Dr. George P. Merrill, head curator of the department of geology, U. S. National Museum, addressed the society on "Meteorites." The phenomena of a fall, history of the study of meteorites, types, structure, mineralogical and chemical composition, and probable origin were discussed in detail. The fragmental character of most stones was noted, and the theories to account for chondrules were reviewed. Of especial interest was the description of the Cumberland Falls, Ky., stone which fell in April, 1919, whose characters showed that the stone had been part of a very large body. The address was illustrated with a large series of lantern slides of photographs of various meteorites and thin sections. After a discussion of the subject, the speaker was tendered a rising vote of thanks.

S. G. GORDON, *Secretary.*

NEW MINERALS

Ferrazite

T. H. LEE and L. F. DE MORAES: Ferrazite, a new associate of the diamond, *Am. J. Sci.* [4], 48 (5), 353-354, 1919.

NAME: After Dr. J. B. de A. Ferraz.

PHYSICAL PROPERTIES: Color, dark yellowish white; sp. gr. 3.0-3.3; in favas (heavy-mineral pebbles). Under the microscope shows a peculiar structure.

CHEMICAL PROPERTIES: Analysis gave: H₂O 14.20, PbO 45.63, BaO 8.87, CaO tr., Al₂O₃ 3.48, P₂O₅ 26.24, SiO₂ 2.44, sum 100.86%. After deducting several per cent. of "kaolinite" and "wavellite," the balance has the composition: 3(Pb, Ba)O.2P₂O₅.8H₂O.

REMARKS: [This seems so obviously a mixture that it is hardly deserving of a special name; the day has long passed when a mineral species can be established by an analysis, no matter how accurate, on a massive specimen not fully studied optically or demonstrated otherwise to be homogeneous. AB-TRACTOR].

S. G. G.

ABSTRACTS—CRYSTALLOGRAPHY

In 1914 Professor Victor Goldschmidt began the publication of a new journal, *Beiträge zur Krystallographie und Mineralogie* (Contributions to crystallography and mineralogy) to appear in numbers containing about 40–50 pages each, at irregular intervals. The breaking out of the war delayed the arrival of this journal in this country, but it is now being received. Abstracts of the articles in the first two numbers are given here, and as soon as subsequent numbers reach us their contents will be abstracted also.

CRYSTALLOGRAPHY AND MINERALOGY. V. GOLDSCHMIDT. Heidelberg. *Beitr. Kryst. Min.*, 1 (1), 1–9, 1914.

A brief account of the history of crystallography and mineralogy and their relations to one another is given. Some of the purposes of crystallography are outlined: As a descriptive science; "biology" of crystals; crystallography and molecular physics; contact mechanics of crystals; mechanics of the solution process; the contrasted mechanics of organisms; crystallography, optics, use of X-rays for crystal study; relation to chemistry; relation to other sciences and industries; and relation to philosophy of nature. "If we look back and review the high aims, to which our science so successfully strives, we may well say that it ranks beneath no other science, and that an aspiring spirit, a real man, may well dedicate the whole of his living and creative power to its service."

E. T. W.

ETCHING AND SOLUTION EXPERIMENTS ON ALUM. HANS BAUHANS. Heidelberg. *Beitr. Kryst. Min.*, 1 (1), 11–40, 4 plates, 1914.

A description of elaborate experiments, made chiefly with potassium alum crystals. The purposes of the investigation were: to study the etching phenomena on individual faces of alum from new points of view; to test out the validity of the laws of etching of crystals formulated by Professor Goldschmidt; and to determine whether the inferences drawn by Fersmann and Goldschmidt from their work on natural etching phenomena on diamond could be experimentally demonstrated.

The alum crystals were etched by warmed or diluted mother liquor, special attention being paid to the circulation of the liquid, it being found that this had considerable influence on the form ultimately obtained. Faces not present originally were cut upon crystals by means of the 2-circle grinding goniometer. The etched crystals were studied on the 2-circle goniometer, some with the cube face in polar position, others with an octahedron so placed. A point signal and diminishing lens combination were used, and the objective brought close to the crystal. The reflection effects shown were sketched on black paper with yellow crayon, and all types of points and fields were subsequently drawn in gnomonic projection. The features shown by the different faces are described in detail. Spheres of alum were also submitted to solution, and gave effects which could be correlated with those obtained on the crystals.

The effects obtained on alum were closely similar to those shown by diamond crystals, and it is concluded that the peculiarities shown by diamond have arisen thru solvent action. Three-sided pits such as observed on diamond are shown on alum to be not growth figures, as often supposed, but to be etching

phenomena. The most important zones of alum, as of diamond, proved to be first $p:p$ and then $p:c$. The rounded hexoctahedron of diamond is found by observations of alum to represent the end-form of etching.

Etching figures proved to develop best on the most important forms, as had been observed previously with certain minerals. They form most readily on p , next on c , and finally on d . The reflections from etching figures stretch over the principal zones of the natural evolution of forms; $p:d$ is most important, and next $p:c$. The reflections from solution faces curve to both sides of the zone lines, and leave significant vacant spaces.

The pentagonal hemihedrism of potassium alum is weak; but with the aid of artificially cut faces of (012), it was possible to distinguish the + and - forms. Cesium alum is, however, strongly hemihedral. It is noteworthy that etching can thus indicate the relative strength of hemihedrisms; and that hemihedrism varies in strength thru the isomorphous series of alums.

The paper is illustrated by excellent figures.

E. T. W.

RELATIONS BETWEEN CRYSTAL SURFACES AND REFLECTIONS; METHODS OF REFLECTION ANALYSIS. PAUL BERBERICH. Freiberg. *Beitr. Kryst. Min.*, 1 (2), 43-70, 1914.

A detailed treatment of the relation of the shape and character of a crystal surface to the reflection produced by it in the goniometer. The definite relations which exist are first discussed, with special reference to the types of curvature to be expected in reflections from faces showing various curves. A method of analysis is discussed theoretically, and also as to its practical application to the goniometer. It is pointed out that the goniometer reverses the position of curved faces; that whether a curvature is concave or convex can be ascertained by inserting a shutter in the eyepiece; the radius of curvature can also be estimated by the rapidity with which the image changes. A number of practical details of manipulation are described.

E. T. W.

TOPAZ FROM MINAS GERAES, BRAZIL. V. GOLDSCHMIDT and V. ROSICKÝ. Heidelberg and Prague. *Beitr. Kryst. Min.*, 1 (2), 71-77, 1 plate, 1914.

On 64 crystals 28 forms were observed, of which two are rare and have only recently been recognized, and two are new: W : (061) and o : (445). The crystals are clear, with brilliant surfaces, and are doubly terminated. Many are short prismatic, some domatic, some tabular on c , and some even approach equidimensional habit. Altho there is considerable variation in the relative sizes of different faces of the same form, there is no regularity in this respect which could be interpreted as indicating hemimorphism. The harmonic series shown by two of the zones are discussed, and descriptions of the form development of 20 typical crystals are given. Interesting form relations, and etching figures, with their reflections, are illustrated.

E. T. W.

THE RANKING OF TWINNING LAWS, ILLUSTRATED BY ARSENOPYRITE. V. GOLDSCHMIDT. Heidelberg. *Beitr. Kryst. Min.*, 1 (2), 79-86, 2 plates, 1914.

When more than one twinning law occurs in the same substance, the different laws necessarily vary in rank. To determine in a given case which is most probable, important, and of highest rank, the following procedure is

suggested: Prepare a gnomonic projection of the observed forms of the crystal species in one position; in the same drawing, prepare an identical projection in a second position, according to law A; observe coincidence of points and zones in the composite projection; repeat this for law B (and any others). That law in which the greatest number of coincidences occurs is the highest in rank. Details to aid this process in special cases are given. The method is illustrated by a discussion of the 4 laws to be expected in arsenopyrite (2 of which are known). In this mineral twinning plane e (101) is found to be most important, and observation on a number of crystals shows it to be in fact somewhat more frequent than the other. An interesting point is brought out,—that paucity of forms and variation in angles, which usually accompany the formation of composite crystals, are both present in arsenopyrite; perhaps the angle variation is due not to variable composition, but to obscure composite-crystal formation.

E. T. W.

AZURITE CRYSTALS FROM MINERAL HILL, NEAR CONDOBOLIN, NEW SOUTH WALES. C. ANDERSON. Australian Mus., Sydney. *J. Proc. Royal Soc. New S. Wales*, **51**, 275–287, 1917.

Specimens from the Iodide Mine, Mineral Hill, consist of oxidized minerals such as limonite, cerussite, malachite, azurite, etc. The azurite is well crystallized, the crystals averaging 0.5 cm. in length, and being attached to the matrix by one end of axis b ; 18 of these crystals were measured on the two-circle goniometer. A total of 21 forms was obtained, one of them, X (481) being new to the mineral. The features shown by these forms are described in detail. The Schrauf elements for azurite, measured on crystals from Chessy, France, are usually accepted, but values obtained on crystals from other localities are distinctly different, a and c being larger. The present crystals are close to those from such localities as Bisbee, Arizona, and Broken Hill, N. S. W., the average values being: $a:b:c = 0.8572 : 1 : 0.8858$; $\beta = 87^\circ 35'$. Figures showing the development of 10 crystals are given.

E. T. W.

THE OPTICAL PROPERTIES OF MAGNESIUM CHLOROPLATINATE. PAUL GAUBERT. *Bull. soc. franc. min.*, **40**, 177–182, 1917.

Crystals with $7H_2O$ were studied, and altho the amount of water and consequently the refractive indices vary with the moisture content of the atmosphere, measurements were obtained, the indices for D being: $\omega = 1.561$, $\epsilon = \text{approx. } 1.91$. Data for some double cyanoplatinates are also given.

E. T. W.

ISOMORPHOUS MIXTURES. PAUL GAUBERT. *Compt. rend.*, **167**, 491–494, 1918.

An extended study of the properties of isomorphous mixtures of chlorates with permanganates and of chromates, sulfates, and selenates with manganates.

E. T. W.

THE SYN-CRYSTALLIZATION OF POTASSIUM AND AMMONIUM NITRATES AT ORDINARY TEMPERATURES. CAILLART. *Bull. soc. franc. min.*, **41**, 21–30, 1918.

From aqueous solutions it was possible to obtain mix-crystals with the form of both end members. Equilibrium data are given.

E. T. W.

THE INFERENCES FROM THE GEOMETRICAL STRUCTURE THEORIES AND THE RESULTS OF ANALYSIS BY ROENTGEN RAYS. W. VOIGT. Univ. Göttingen. *Physik. Z.*, 19, 237-247, 331-343, 357-366, 446-462, 1918.

An elaborate discussion of the geometrical theory of space-lattices, symmetry classes of crystals, etc., with a summary of the results of X-ray study.

E. T. W.

THE COHESION OF CRYSTALS AT THE TEMPERATURE OF LIQUID AIR. A. JOHNSEN. Kiel. *Centr. Min. Geol.*, 1918, 233-235.

Observations were made upon calcite, gypsum, halite, gold, silver, copper, and muscovite. Cooling with liquid air decreased plasticity in all but the last.

E. T. W.

ABSTRACTS—MINERALOGY

APPARATUS FOR PRODUCING ULTRA-VIOLET RADIATION. W. S. ANDREWS. *General Electric Review*, April, 1916.

A description of a transformer for producing a spark between iron terminals, which is rich in ultra violet light, and produces fluorescence and phosphorescence in many minerals and other substances.

E. T. W.

AN IMPROVED FORM OF PHOSPHOROSCOPE. W. S. ANDREWS. *Gen. Elec. Rev.*, March, 1917.

A description of an apparatus in which ultra-violet light is produced by an intermittent spark between iron terminals; the powdered mineral or salt can be viewed thru one eyepiece continuously, and any fluorescence seen; and thru another only while the spark is interrupted, to observe phosphorescence.

E. T. W.

AN APPARATUS FOR SEPARATING VISIBLE FROM INVISIBLE LIGHT. W. S. ANDREWS. *Gen. Elec. Rev.*, October, 1917.

Taking advantage of the fact that a lens brings light of different wavelengths to a focus at different points, an iron spark producing light rich in ultra-violet is placed at one side of a quartz lens, and a metal plate pierced by a pinhole at the focus of the ultraviolet rays on the other side. By this means most of the visible light from the spark is intercepted, while the ultra-violet gets thru, and will produce fluorescence in a mineral placed beyond. The true color of the fluorescent light can then be determined.

E. T. W.

THE LARGEST KNOWN BERYL CRYSTAL. W. A. WALDSCHMIDT. S. Dak. Sch. Mines. *Pahasapa Quart.*, 9 (1), 11-16, 1919.

A brief review is given of the occurrence of various minerals, some of them usually considered rare, in large masses or crystals, in the Black Hills region. The largest crystal of beryl heretofore described appears to have been one of 5 tons weight at Grafton, N. H. (*Am. Min.*, 4 (3), 21-22, 1919). One now exposed in the Bob Ingersoll Mine, near Keystone, S. Dak., is probably still larger. It is hexagonal in outline, about 6 decimeters on a side, or 1.2 meters in largest diameter. The color is nearly white, and the specific gravity 2.73. It was originally at least a meter long, and weighed several tons, altho a considerable part has been quarried away. Photographs and diagrams of the crystal are given.

E. T. W.

AN INTERESTING OCCURRENCE OF ISOMORPHOUS SIDERITE AND CALCITE. J. HARLAN JOHNSON. S. Dak. Sch. Mines. *Pahasapa Quart.*, 9 (1), 20, 1919.

In Crystal Cave, on Elk Creek, S. Dak., some calcite crystals and knobs were found containing nuclei of brown siderite. Cleavages up to 7 cm. across were observed. E. T. W.

CACOCCLASITE FROM WAKEFIELD, QUEBEC. N. L. BOWEN. Queen's Univ. *Am. J. Sci.* [4], 48 (6), 440-442, 1919.

From a careful reëxamination of this material it is concluded: Chemical microscopic, and crystallographic evidence all point to the fact that cacoclasite is a pseudomorph (essentially a paramorph) of grossularite after sarcolite, with calcite and apatite filling the voids produced by the reduction of volume involved in the change. S. G. G.

AN INTERESTING OCCURRENCE OF MANGANESE MINERALS NEAR SAN JOSE, CALIFORNIA. AUSTIN F. ROGERS, Stanford Univ. *Am. J. Sci.* [4], 48 (6), 443-449, 1919.

A boulder of manganese ore situated on the bank of Penetencia Creek, below Alum Rock Park, was found to consist largely of pyrochroite, with tephroite, hausmannite, ganophyllite, rhodochrosite, barite and psilomelane, the latter forming a crust on the exterior of the boulder. The boulder undoubtedly represents a block (probably of Franciscan age) detached from its original location in the hills above in some past period. The paragenesis of the minerals is discussed. S. G. G.

NOTES ON METEORITES. ALEXANDER SCOTT. North Staffordshire Field Club, *Trans. & Ann. Rept.*, 53, 35-45, 1918-1919.

The composition, structure, and origin of meteorites are discussed.

S. G. G.

METEORIC IRON FROM DEHESA, CHILE. F. BERWERTH. *Min. petr. Mitt.*, 34, 272, 1916; thru *J. Chem. Soc.*, 114, ii, 403, 1918.

New data presented shows this iron to be a very fine octahedrite.

E. T. W.

FURTHER NOTES ON THE PLAINVIEW, TEXAS, METEORITE. GEORGE P. MERRILL. *Proc. U. S. Nat. Mus.*, 54, 503-505, 1918.

The stone proves to be a breccia of two types of material, apparently of distinct origin. One of these appears to have been friable, and on compression the two have been mixed, so as to obscure the brecciation. E. T. W.

THE EFFECT OF TIME AND TEMPERATURE ON THE MICROSTRUCTURE OF PORCELAIN. ALBERT B. PECK. Bureau Standards. *J. Am. Ceram. Soc.*, 2 (3), 175-194, 1919.

Petrographic-microscopic examination has been made of porcelain burned for different lengths of time. The clay passes into amorphous silica and sillimanite, and the latter then crystallizes; quartz may dissolve in the feldspar. Sillimanite also crystallizes from solution in feldspar flux. E. T. W.